ESME Workbench Enhancements

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LONG-TERM GOALS

The goal of the ESME Workbench project is to create a general purpose simulation tool for use by those who wish to study the effects of sound in the marine environment.

OBJECTIVES

The major objectives of the project are to:

1) Develop a sophisticated user interface that allows the user to visualize the environmental parameters used for acoustic propagation calculations as well as the results of these calculations and then to visualize the location of sound sources and animats during scenario simulations.
2) Incorporate acoustic propagation algorithms for simulating both low-frequency and high-frequency sound sources
3) Provide a detailed log of exposures for each animat organized by source and to provide basic summary statistics for each simulation.

APPROACH

The ESME Workbench is a software system designed with industry-standard best practices in interface design, modularity, testability and code reuse. Figure 1 illustrates the overall architecture of the software system. Except for a few components that were not developed by the authors, all subsystems where implemented using C# and .NET.

The ESME Workbench can be divided into several major subsystems: a database that stores simulation parameters, a collection of data files that define acoustic, biological, and environmental data, and a suite of plugins to compute sound propagation, define environmental parameters, predict sound output, and represent simulation output graphically.

The ESME database contains all data and metadata necessary to describe any scenarios that have been defined by the user. The data needed to describe a scenario consists of a location, environmental data

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at that location, a set of active acoustic sources and associated behavioral data, a set of species to be exposed to those acoustic sources, and a set of acoustic simulations intended to model the sound field produced by those sources.

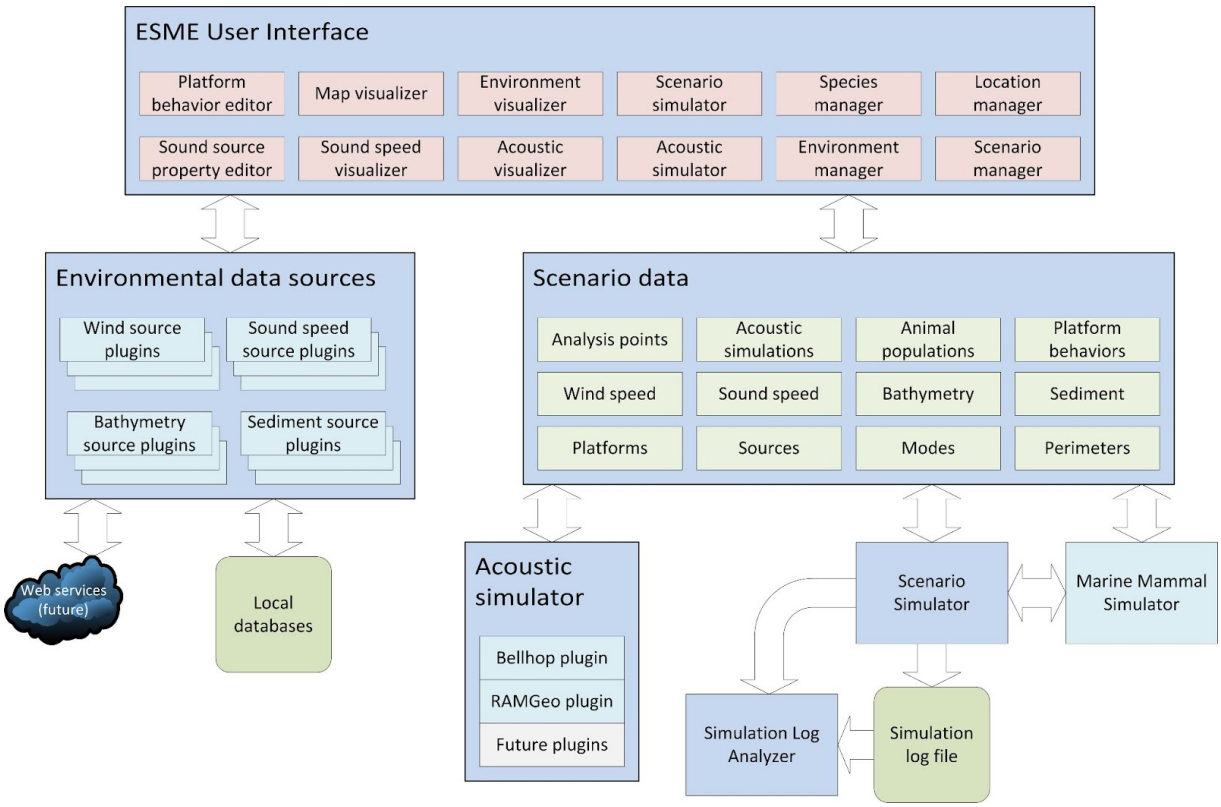

FIGURE 1. ESME Workbench architecture. Within the major subsystems, the red boxes are components of the user interface.The light blue components are components that ESME uses but were not developed by the Boston University team. Green boxes indicate data that are stored on disk

Some of these data are stored in a relational database, and some are stored external to the database in binary files. External files were used in cases where using the database did not make sense from a performance or space efficiency perspective.

All scenarios are built inside a geographic bounding box, formed by the northern, southern, eastern and western edges of the simulation area. This extent information is called a Location. Multiple scenarios can share a single Location. The scenario is the basic unit of simulation in ESME. A fully specified scenario is linked to a specific, already-defined Location and contains the following information:

- **Platforms**. A platform is a container for one or more active acoustic sources. Platform types include surface ships, submarines, and aircraft. Platforms can either be stationary or have certain predefined behaviors.
- **Sound Sources.** Each platform has one or more Sources. A source is intended to reflect a physical system that puts sound into the water. A sonar system or a depth sounder would be good examples of Sources.

- **Sound Source Modes**. Each source has one or more Modes. A mode is intended to reflect a distinct operational mode of a particular Source. For example, if the Source is a mid-frequency sonar system, then a specific mode would be defined by its beam pattern, frequency, ping duration, and repetition rate. The Modes defined in a scenario should reflect the desired acoustic settings of any systems that will be active during the simulation
- **Platform Perimeters**. If any platforms will be moving about randomly in the scenario, one or more Perimeters must be defined. A Perimeter is simple polygon that is completely contained within the location boundaries. Multiple Platforms may be associated with any given Perimeter.
- **Acoustic Analysis Points**. An analysis point is a location at which every acoustically distinct Mode will be simulated by the acoustic simulator. As the scenario simulator runs, the closest Analysis Point at each simulation time step is used to calculate the exposures for each animal.
- **Marine Mammal Species**. Each species specified also has a population density. The individuals in each species can (optionally) have their behavior simulated during the scenario simulation, using the Marine Mammal Movement and Behavior Simulator (3MBS) [3], which is included in ESME.

WORK COMPLETED

Software enhancements

- Released ESME Workbench 2012
- Made ESME culture-invariant
- Added optional comprehensive logging with selectable control to assist debugging during software development or to debug a specific user's problem.
- Added a native histogram plotting library (removed all matlab dependence)
- Made ESME significantly more robust against state-dependent crashes
- Saveable and serializable scenarios
- New ship movement model (custom tracks)
- Added RAMGeo beamforming

User Interaction

- Closed 15 filed bugs filed by researchers across the world.
- Created an ESME listserv
- Expanded the website with a user interest survey
- Made contact with multiple academic and non-academic groups
- Met with a few interested groups to explain and discuss ESME features and use
- 1600 visitors to the website, 900 of which were new. 55% direct traffic (people who already knew the URL). Most common search terms for the remaining 45%: "ESME BU", "esme download", "esme mammal", and "gdem".
- 49 downloads of the Matlab API (users interested enough to want to do custom analysis)

- 207 downloads of ESME itself.
- Presented an ESME overview at ICA 2013 and ran a demonstration of how to use the ESME software

RESULTS

- Released ESME Workbench 2012: This is the first, fully-featured release of the software and is currently going through the NMCI certification process so that it can be used by Navy personnel.
- New ship movement model: This provides the user with the capability of defining customized ship tracks. This capability can be used either for simulations intended to predict the impact of future naval training exercises or to study if or why a specific training exercise caused a stranding or other adverse impact on marine mammals
- Added RAMGeo beamforming: RAMGeo is a propagation algorithm which is used for situations where the source frequency is too low for the Bellhop ray-tracing algorithm to produce accurate results.

IMPACT/APPLICATIONS

The ESME Workbench will provide naval personel and contractors with a user-friendly desktop application that can be used to evaluate the potential impact of proposed activities on marine mammals. It can be used to provide "quick-looks" for projects that will need to go through an extensive simulation process in order to comply with environmental reporting requirements.

TRANSITIONS

NMCI certification is in progress and is expected to be completed in November, 2013.

RELATED PROJECTS

None

PUBLICATIONS

Mountain, D., Anderson, D. and Voysey, G. (2013. The effects of sound in the marine environment (ESME) workbench: A simulation tool to predict the impact of anthropogenic sound on marine mammals**.** POMA **19**, 010051; http://dx.doi.org/10.1121/1.4801015